U.S. Test and Evaluation in the New Millennium

Dwayne Cox

Test, Systems Engineering and Evaluation/Resources and Ranges,
Office of the Secretary of Defense

The Office of the Secretary of Defense is meeting the challenges presented by declining investments in test and evaluation (T&E) and increasing test requirements by relying heavily on the Central Test and Evaluation Investment Program (CTEIP). This paper describes the CTEIP, its objectives and vision for U.S. T&E over the next millennium, as well as how the CTEIP instrumentation development, implementation and integration strategy will facilitate joint testing with U.S. allies in the global arena.

In 1989, to improve the coordination and planning of investments in defense test and evaluation (T&E) facilities, the Office of the Secretary of Defense (OSD) established the Central Test and Evaluation Investment Program (CTEIP). The CTEIP was designed to provide a corporate approach to investing in defense T&E needs. Allocating testing resources on the basis of corporate rather than service-level criticality not only promotes increased interoperability and interconnectivity among test centers and ranges, it also focuses T&E expertise on test matters as well. Unwarranted duplication of effort is eliminated, and and the result is better use of scarce assets and resources.

CTEIP overview

The recent trends in investment in defense T&E have made the CTEIP extremely valuable in meeting defense test requirements. As overall investments in test infrastructure and capabilities decrease, the share of these investments provided by the CTEIP increases. As the only Department of Defense (DoD) program that provides a coordinated process for making investments in joint T&E, the CTEIP has increased in importance in the current fiscal environment. The exponential rise in the technical complexity of weapons systems that must be tested, along with the potential for further encroachments to range resources—such as land and frequency spectrum—have both ensured that the CTEIP remains uniquely valuable.

The CTEIP's immediate objectives are to maximize and leverage test investments to increase jointness; to eliminate duplicative efforts; and to use scarce assets and resources with utmost efficiency. These objectives are realized through a corporate investment approach that is specifically tailored to:

- Support joint test projects that apply state-of-the-art technologies to *correct deficiencies* in DoD T&E capabilities and *improve the efficiency of the test process.*
- Maximize efficient inter-service use of test assets by improving *interoperability and interconnectivity* among test centers, ranges and facilities.
- Establish and maintain a program to investigate, develop and produce prototypes of advanced technology for application to T&E that *reduce manpower requirements, operating expenses, maintenance requirements and other costs.*
- Achieve *consistency, commonality and interoperability across the military services* in test instrumentation, targets and threat simulators. Develop, validate and *integrate modeling and simulation (M&S)* with open air testing to provide accurate, timely and cost-effective results.
- Exploit *capabilities in mobile test instrumentation as an alternative to fixed facilities*, where economically and technically feasible.
- Provide resources to *respond to critical near-term operational test capability shortfalls.*

CTEIP support of corporate strategy for T&E resources and investment

In 1998, the OSD issued a Corporate Strategy for T&E Resources and Investments that articulated a vision to "enable the fielding and use of affordable, superior weapons that are developed and tested in modern, efficient T&E facilities to support tomorrow's readiness." To realize this vision, the strategy has set four goals:

(1) A strong T&E infrastructure for efficiency and productivity

(2) A foundation for the future T&E infrastructure

(3) A corporate investment process integrating all DoD processes

(4) Strategic partnerships

The CTEIP fundamental objectives outlined earlier clearly overlap and support the goals of the corporate strategy: They seek to apply new technology to build a modern and efficient T&E infrastructure; and they attempt to facilitate joint financing and partnerships. The CTEIP projects are selected via a process that ensures the active participation of all concerned and fosters a robust competition for assets. Emerging technologies are applied to test requirements both to increase efficiency and productivity and to provide the foundations to modernize the test infrastructure.

The structured process by which candidate projects are chosen integrates the T&E community's investment process with those larger DoD investment processes. In addition, the CTEIP provides an arena in which to develop strategic partnerships with acquisition managers, enabling them not only to share test technology and resources—thus reducing investment expenditures—but also to provide opportunities for joint ventures as well. Strategic partnerships between the test and the training communities also are emerging under the aegis of the CTEIP. Shared test and training interests are recognized in such areas as the joint acquisition of range instrumentation. In addition, the potential application to training of technology developed within the CTEIP is receiving increased emphasis.

CTEIP project categories

The CTEIP consists of three project categories: Joint Improvement and Modernization (JIM) projects; Test Technology Development and Demonstration (TTD&D) subprojects; and Resource Enhancement Project (REP) subprojects.

■ ***JIM Projects*** consist of investments to improve the test capability base. JIM projects represent critically needed T&E investments in the major functional areas of test mission command, control, communications and instrumentation; electronic warfare systems; threat and computational simulation T&E; space system T&E; weapons effects test capabilities; targets; and physical and environmental test capabilities. The investments are made in the development of advanced technologies needed to test increasingly complex and sophisticated systems. Such technologies include automated data collection, processing, display and archiving; smart munitions testing; simulation and end-game measurement; advanced materials applications; test design; and advanced sensors and space systems.

■ ***TTD&D Subprojects*** are intended to facilitate the transition of mature technologies from laboratories to satisfy T&E needs. Selection of a technology subproject is based on its ability to test high-technology systems and upgrades, broad-based applications to foster interoperability among test centers, transportability, efficiency of operation, as well as application at multiple DoD ranges or defense agencies. Prime consideration is placed on high payback from projects in terms of better decision-making data, increased testing efficiencies, greater safety, labor savings and reduced maintenance costs.

TTD&D subprojects are primarily in the categories of range instrumentation and test and range architecture. Subprojects selected for funding under TTD&D are expected to be available for transition to field use within two to four years of initial funding. The T&E community is provided with the equipment and methods to test and thoroughly evaluate new weapons systems that are evolving from advanced research and development and technology initiatives. Application of new technologies will result in more interoperable instrumentation systems; more easily transportable instrumentation; and significant economies of operation due to reduced labor, material and maintenance costs.

■ ***REP Subprojects*** are funded under the CTEIP to provide quick-reaction, near-term solutions to operational test shortfalls in support of ongoing system acquisition or product improvement programs. The need for the specific capability generally is not known more than three years in advance of the operational test requirement. Involvement by the Director of Operational Test and Evaluation (DOT&E), military services and DoD agencies in REP subproject identification, selection and execution oversight ensures optimal use of the developed or acquired capability, as well as melding with the DoD T&E investment strategy. Since 1991, REP has funded a variety of investments in instrumentation, targets, threat simulators, threat systems, data collection and processing systems and other related operational T&E capabilities. These investments provide critical operational test capabilities used by DoD testing organizations located across the nation.

CTEIP success stories

The following accounts provide a brief overview of some of the more recent CTEIP joint-service success stories. They illustrate the types of efforts that will continue into this next century.

■ ***Weapons Modification and Simulation Capability (WMASC)***—WMASC-developed tools, as shown in *Figure 1*, have achieved an extensive integration into the tri-service aircraft compatibility and related T&E processes. Computerized Physical Fit Plus (CPF+) and Applied Computational Fluid Dynamics (ACFD) routinely are used in service-funded engineering and analysis functions. The estimated dollar savings achieved through a robust application of CPF+ and ACFD exceeded $12 million over the past year. In addition, valuable engineering data are provided to the the various weapons systems' prime contractors. This simulation-based acquisition function, funded by the respective program offices, has been an effective tool in minimizing costs and in reducing schedule for the contractors.

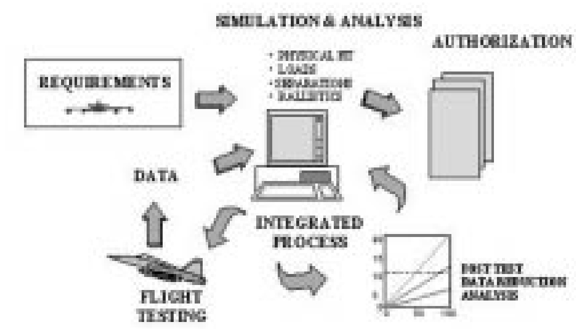

Figure 1. Weapons Modification and Simulation Capability (WASMC) process

■ ***Advanced Static Radar Cross Section (ASRCS) Measurement System***—In 1998, the final design and development of the Bistatic Coherent Measurement System (BICOMS) was completed under this project at the Radar Target Scatter (RATSCAT) facility at Holloman Air Force Base, New Mexico. A state-of-the-art broadband, monostatic and bistatic radar cross-section measurement system, BICOMS consists of instrumentation located at three primary sites: a fixed radar unit (FRU), a mobile radar unit (MRU) and target pit areas. During 1998, all subsystems were developed and integrated into the FRU and the MRU and then installed at RATSCAT for acceptance testing and training.

■ ***Airborne Separation Video (ASV)***—The first phase of this project, the development of a Near-Term Test Capability (NTTC) camera, saw the successful completion of acceptance testing at the contractor facility. In addition, the first-ever flight tests of a high-speed digital imaging camera were conducted on a Navy F/A-18C and an Air Force F-16 aircraft in 1998. These flight tests confirmed the advantages of near-real-time and real-time imaging and provided data quality images. Tests comparing NTTC camera images with digitized images from 16-millimeter film cameras showed that the ASV images were equal to, if not better than, those provided by film. As a result of these tests, the NTTC camera has moved into low-rate initial production. Cameras and equipment have been purchased by individual military services for use on the F-16 (Air Force), Kineto Tracking Mount (KTM) (Army) and the F/A-18E/F follow-on tests program (Navy). Several foreign military users have expressed significant interest as well.

■ ***GPS Jammers***—The Navy portion of the Global Positioning System (GPS) Jammers subproject was used successfully to support testing of the Stand-Off Land Attack Missile-Expanded Response in February 1998 and the B-1 Joint Stand-Off Weapon in September 1998 at White Sands Missile Range, New Mexico. The Army's GPS Jammers radiate controllable and instrumented GPS jamming signals that provide the reference time, signal strength, frequency waveform, mode of operation, magnetic or true coordinate antenna pointing angles, as well as latitude and longitude vehicle location. The Army GPS Jammers are scheduled to support the operational test of the Multiple Launch Rocket System, Near-Term Data Radio and Comanche.

■ ***Modeling, Simulation and Tool (M, S&T) Support to OT&E***—This subproject provided the Joint Interoperability Test Command with the capability to collect reliable performance data statistics, refine constructive simulations using actual performance data and perform analysis beyond the capability provided by available manpower and equipment. The M, S&T Support to OT&E was used extensively to support the initial operational T&E of Defense Message System (DMS) version 1.0, limited user functional test of version 1.1 and operational assessment of DMS versions 2.0 and 2.0A. These tools also were used to support the operational testing of the Global Command and Control System 3.0 Stage I and provided information to establish this version as the system of record. They also provided router configurations and performance data as an input to the Defense Information System Network (DISN) constructive simulation models to perform additional DISN vulnerability and survivability assessments.

■ ***Video Tracking System (VTS)***—This subproject integrated an eye-safe laser rangefinder, a GPS, a meteorological station and associated software into an existing KTM, providing the Army with the capability to track multiple independent parachutes and airdrop cargo from a single tracking station. VTS has successfully video tracked, received laser returns and calculated real-time time space position information data from various targets of opportunity. VTS also supported the C-17 aircraft multi-service testing in August 1997, as well as Airdrop Parachutist Combat Equipment Load and Low-Velocity Airdrop (LVAD) testing.

Some key ongoing CTEIP projects

Many projects are key to achieving the CTEIP vision. The following projects were chosen in particular to illustrate the depth and breadth of the CTEIP investments.

The Foundation Initiatives

The Foundation Initiative 2010 project is developing and validating the core products to enable the interoperability necessary to create synthetic battlespaces consisting of actual weapon systems at multiple ranges, system components in hardware-in-the-loop facilities, and/or simulations of weapon systems. The Foundation Initiative is developing and validating a common architecture, a core set of tools, inter-range communication capabilities, interfaces to existing range assets and a repository of reusable software, along with recommended procedures for conducting synthetic exercises. The common architecture, referred to as the Test and Training Enabling Architecture (TENA), will be compliant with the DoD High-Level Architecture (HLA) for simulations. It will address areas of test not supported by HLA and will drastically improve the core set of ranges to interact with simulations.

Requirement—In order to support the war-fighting community, both interoperability and reuse of resources within the test community are needed to validate weapon system requirements in a cost-effective manner. Resource constraints (safety, funding, environmental and treaty-compliance) often limit live testing to the collection of a few critical data points. Without complementary M&S capabilities, this may result in the fielding of future war-fighting systems that do not fully meet operational requirements. Incorporating all design considerations, the DoD is adopting a simulation-based acquisition process to reduce time, risk and cost of development for future weapon systems.

Benefits—The overall capabilities of the Foundation Initiative 2010 will promote interoperability and reusability among DoD ranges, facilities and simulations. These capabilities will advance a simulation-based acquisition methodology to streamline weapon system acquisition. Most important, once the Foundation Initiative 2010's capabilities are in use by the test and training communities, future inter-range operations, as well as instrumentation development and sustainment, will cost less and incur less risk. The benefits from these products include cost-effective replacement of customized datalinks, enhanced exchange of mission data, organic HLA capability at sites to be leveraged for future HLA/TENA events and software reuse.

Advanced Range Telemetry (ARTM)

The ARTM project's objective is to improve the efficiency and reliability of DoD flight test telemetry links. Investigating and developing telemetry technologies such as higher order modulation techniques, data compression, error coding and correction, improving frequency scheduling tools and air vehicle antennas will accomplish this objective.

Requirement—Requirements for real-time aircraft and missile test telemetry data have grown exponentially. This is primarily due to the increased technical complexity of weapons systems and military air vehicles. As the complexity grows, more real-time flight test data are required to maintain today's level of test safety and efficiency. In addition, the electromagnetic spectrum allocated to aeronautical flight test has decreased over the past few years and continues to be threatened by the commercial telecommunications industry. The DoD test and training community must continue to satisfy customer needs for higher throughput and improved reliability of real-time telemetry data—in a limited spectrum environment—in order to minimize the cost and schedule impacts to aeronautical test operations *(Figure 2)*.

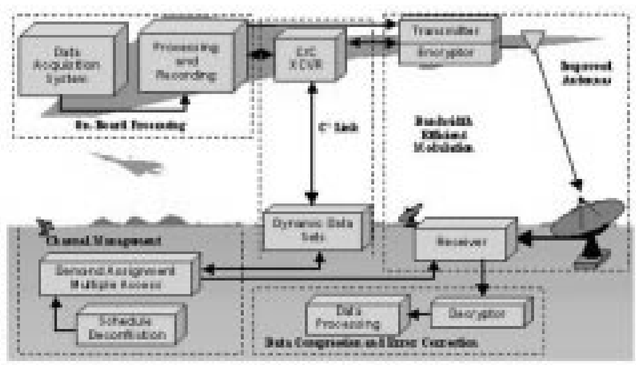

Figure 2. Advanced Range Telemetry (ARTM) system-level diagram

Benefits—The major benefit of ARTM is the expanded capability it will provide for test ranges. Another key benefit of ARTM will be commonality. Through cooperation and standardization, major DoD ranges have established common, interoperable telemetry systems. These provide a baseline that can be improved only through a tri-service development effort such as ARTM. Cost savings will be realized through joint development, production and sustainment.

Hardened Subminiature Telemetry and Sensor System (HSTSS)

The HSTSS project will develop and demonstrate a new generation of rugged, miniaturized, onboard instrumentation applicable to weapon system flight tests. The technologies will be relatively low-cost and will consist of several configurations designed to accommodate applications in the direct fire, indirect fire and missile system mission areas.

Requirement—Comprehensive measurement devices do not exist for very high-G projectile systems. Specific performance data such as acceleration, roll, pitch and yaw rates, pointing angle at detonation, launch pressure on projectile base and internal functioning currently cannot be collected routinely and efficiently at DoD test ranges. Therefore, new methodologies and hardware must be developed to capture these measurements in a high-G environment. The device must provide continuous data from launch to impact, be non-intrusive to the unit-under-test, have a self-contained power source and use standard transmission formats.

Benefits—The HSTSS project will provide the Army, Navy and Air Force with an entirely new high-G instrumentation capability. The HSTSS devices have low power requirements, are inexpensive and will provide attractive features to lower-G systems such as missiles and smart bombs, where space and power limitations are severe. Advanced technologies used in the HSTSS project include lithium-ion polymer flexible power supplies, hardened L- and S-band transmitters, multi-chip modules, micro-electromechanical sensors and inertial measurement units.

Multi-Service Target Control System (MSTCS)

The MSTCS project's goal is to upgrade existing tri-service target control systems while providing interoperability. The MSTCS concept will build on the work accomplished by the Next-Generation Target Control System (NGTCS) project, which was canceled in 1998 when its approach proved too costly to implement.

Requirement—In testing and training scenarios, it is necessary to present multiple configurations of both surface and aerial targets in an electronically dense environment. Creating and controlling these scenarios has taxed target control systems to the point where some are unable to cope with current test and training scenarios and are wholly inadequate for meeting future requirements. Currently, a variety of target control systems (TCS) are employed on ranges around the world. Each of these systems performs similar functions and may control the same classes of targets. However, they are not interoperable. Each of the principal ranges offers some unique environmental features that make target interoperability desirable. A need also exists to immediately upgrade deficient TCSs and to improve future supportability of all such systems.

Benefits—The GPS-based MSTCS System will provide: tri-service interoperability; enhanced capability compared to each of the military services' existing target control systems; and maximum utility, while minimizing premature obsolescence, by designing with the newest, most affordable technology.

Transportable Range Augmentation and Control System (TRACS)

The TRACS project will develop a suite of transportable equipment and instrumentation of common-range control functions *(Figure 3)*. This suite will augment existing test ranges in supporting DoD programs such as ballistic missile test programs during multiple, simultaneous engagements.

Figure 3. Transportable Range Augmentation and Control System (TRACS) equipment

Requirements—In order to conduct developmental and operational flight T&E of future DoD systems, a transportable suite of instrumentation is required to augment test support capabilities at existing DoD ranges, and to provide capabilities at ranges and remote test areas that have little or no basic instrumentation infrastructure. A system is needed to satisfy multi-service range support requirements for ballistic missile defense and other testing requirements beginning in Fiscal Year 2000 and continuing beyond Fiscal Year 2010 at multiple locations. The tests to be supported will occur at various locations, including remote sites. Current ballistic missile test ranges do not have enough capability to test the most demanding mission scenarios. An easily transportable or mobile-capable system is required for command, control and communications; integrated range safety; time-space-position information (TSPI) instrumentation; data processing and analysis; and multi-source sensor reception and processing.

Benefits—Downsizing of the DoD infrastructure has made it impractical to modernize, maintain or sustain T&E capabilities for infrequent maximum workload situations and complex scenarios at all potential test locations. The DoD can make more efficient use of resources with an "on demand" capability that supports a test area only when required for live operations, or augments certain parts of an existing range capability as needed. TRACS will provide this surge capacity during periods of maximum scenario requirements. By developing only one set of easily transportable instrumentation, millions of dollars in cost savings will be realized. In addition, reuse of recently developed software at the major DoD ranges avoids developmental cost and uses proven systems.

Joint Advanced Missile Instrumentation (JAMI)

The JAMI project will develop an integrated instrumentation package for applications in tri-service small missile test and training. Components developed will provide telemetry, TSPI, flight termination and end-game scoring in a low-cost, modular package that will allow worldwide test and training. This capability, in most cases, would eliminate the need for range-specific (or multi-system) facilities. JAMI will incorporate GPS-based technology as the TSPI and vector scoring engine, state-of-the-art telemetry and an off-the-shelf ultra high frequency flight termination receiver coupled with a miniature, solid-state programmable safe and arm device. Components will be qualified and tested as an integrated package in a missile system flight test.

Requirement—For testing applications, missiles such as the Advanced Medium-Range Air-to-Air Missile, Rolling Airframe Missile, Standard Missile and the Evolved Sea Sparrow Missile must be instrumented to provide four range functions: telemetry, TSPI, flight termination and end-game scoring. There is no single, airborne instrumentation package that supports all four functions, and the instrumentation that does exist is range-specific. Additionally, a cost-effective solution is needed for older technology end-game scoring systems.

Benefits—JAMI will enhance the capabilities of the test ranges by upgrading the instrumentation of small missile platforms. It will provide added capability to track low-flying targets and missiles that fly below the radar horizon. This will reduce safety risks by providing accurate tracking throughout the duration of flights. JAMI will provide instrumentation to support an end-game scoring solution for the missile-target intercept. Such a capability not only will provide the data to determine lethality performance, but when provided within minutes of the intercept, it will allow the decision to launch another weapon within the same range utilization window. JAMI also will enhance interoperability by reducing the need for unique range infrastructure.

The future

While the CTEIP has an established set of objectives, its leadership has identified additional initiatives that are designed to further the CTEIP contributions to efficient and cost-effective testing. Among them is the *formation of formal networks* through the use of state-of-the-art computers, telecommunications systems and M&S to effectively integrate and leverage T&E assets. The CTEIP also will seek to *increase investments in M&S* to build upon the Defense Modeling and Simulation Office's initiatives aimed at building a common technical framework such as HLA, conceptual models of the mission space and data standards. This will help ensure that T&E assets are able to support the acquisition community's future test requirements.

To maximize the use of scarce test and training investment resources, continued emphasis will be placed on *improving coordination between the test and training communities and with U.S. allies*. As part of this important initiative, the CTEIP will continue to seek opportunities to promote commonality and interoperability between test and training infrastructure and range instrumentation. As an example, the CTEIP is investing in plug-and-play, open architecture instrumentation constructs. This architecture will readily support joint test and training exercises overseas by allowing interchange of datalink modules to accommodate local spectrum availability.

The advantages of a corporate approach to test investments are clearly recognized, and the CTEIP is a model for just such an approach. Through the active participation of the military services and DoD agencies, the CTEIP is uniquely positioned in the vanguard of the effort to meet the test challenges of the future, both technical and fiscal. ❑

Dwayne Cox is a staff specialist in the Office of the Director, Operational Test and Evaluation/Resources and Ranges, Office of the Secretary of Defense. He is the program element manager for the Central Test and Evaluation Investment Program (CTEIP), which funds the development of new test and evaluation capabilities for the Department of Defense and military services. Cox has more than 25 years' experience in aviation and weapons systems testing, most of which was at the Naval Air Warfare Center at Patuxent River, Maryland. He was the lead instrumentation engineer on many programs, such as the F-14, SH-60, CH-53 and F-18 aircraft development programs. Cox managed several test and evaluation facilities and organizations while with the Range Directorate. He also served several years as the Department of Defense reliance lead for airborne instrumentation and as the Navy lead for the Common Range Instrumentation Reliance group. He holds a bachelor's of science degree in electronic engineering and is a graduate of the Program Managers Course at the Defense Systems Management College.